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(71) Applicant: **FIAT AUTO S.p.A.**
Corso Giovanni Agnelli 200
I-10135 Torino(IT)

(72) Inventor: **Varrone, Piergiorgio**
Via Adamello, 11
10025 Pino Torinese(IT)
Inventor: **Burzio, Gianfranco**
Corso Sacchirone, 19
12022 Carmagnola(IT)
Inventor: **Damiani, Sergio**
Via Taggia, 38
10100 Torino(IT)

(74) Representative: **Jorio, Paolo et al**
STUDIO TORTA Società Semplice Via Viotti 9
I-10121 Torino(IT)

(54) Method and device for the detection and classification of the crimpling of a surface treatment.

(57) A method for the detection and classification of the crimpling of a surface treatment, characterized in that it involves, in the following order, the operations listed below:
illumination of an area (6) under examination by means of a luminous beam essentially comprising a plurality of light areas alternated with dark areas and preferably with clearcut edges between the respective adjacent areas;
detection of a beam reflected by said area (6) to be examined using image detector means (15) adapted to explore said area (6) by scansion, so as to obtain an alternative electrical signal on subsequent detection of said light and dark areas;
execution of a mathematical calculation of the gradient and corresponding number of pixels of said signal generated by said image detector means (15), and drawing of a bargraph showing the gradient in function of the number of pixels; and
execution of a comparative analysis of the bargraph, obtained at the end of scansion of said area under examination, with preset reference values.

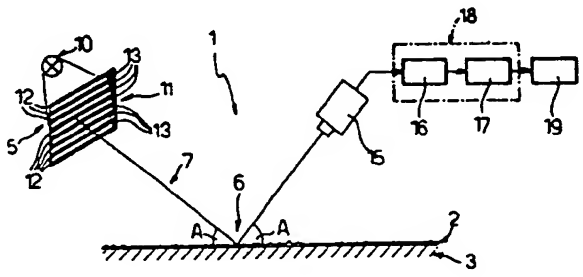

Fig.1

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Method and device for the detection and classification of the crimpling of a surface treatment

The present invention relates to a method and device for the detection and classification of the crimpling of a surface treatment.

More specifically, the present invention relates to a method and device which may be beneficially used for evaluating the aesthetic appearance of a sprayed vehicle body, making improvements to the paint spraying process so as to obtain perfect results, especially as far as the surface spread of the paint is concerned.

As is well known, an incomplete spread of the paint causes a medium-fine grained wrinkle on the surface, with random pitch and direction, resembling orange peel (and said wrinkle is often referred to using this name).

At the present time, the detection and classification of crimpling are performed manually by projecting, onto the surface under examination, lattices comprising light (white) bars and dark (black) bars in alternation and with decreasing pitch. When the observer notes that the paint crimpling distorts the image reflected by the surface under examination so that two adjacent dark bars merge, the [redacted] as the spread value (which normally varies from 0 to 20, where 20 represents a perfect reflection and therefore zero crimpling).

The methods currently employed present drawbacks both from an operational point of view, in that all the operations are performed manually, and as regards the results obtained, as the spread value is attributed in a subjective manner.

It is the object of the present invention to provide a method for the detection and classification of the crimpling of a surface treatment and a device operating on the basis of this method, which overcome the drawbacks of current methods set forth above.

According to the present invention there is provided a method for the detection and classification of the crimpling of a surface treatment, characterized in that it comprises, in the following order, the operations listed below:

illumination of an area to be examined by means of a luminous beam essentially comprising a plurality of light areas alternated with dark areas and preferably with clearcut edges between the respective adjacent areas;

detection of a beam reflected by said area under examination using image detector means adapted to explore said area by scansion, so as to obtain an alternate electrical signal on subsequent detection of said light and dark areas;

execution of a mathematical calculation of the gradient and corresponding number of pixels of said signal generated by said image detector means, and create a bargraph showing the gradient in function of the number of pixels; and

comparative analysis of the bargraph, obtained at the end of an inspection of said area under examination, with preset reference values.

The present invention also relates to a device for the detection and classification of the crimpling of a surface treatment, of the type comprising illuminating means adapted to illuminate an area to be examined of said surface by means of a luminous beam essentially comprising a plurality of light beams alternated with dark beams and with clearcut edges between the respective adjacent areas, said device being characterized in that it comprises:

image detector means adapted to explore said area by scansion, so as to obtain an alternate electrical signal on subsequent detection of said light and dark areas; and

calculating means which execute a mathematic calculation of the gradient of said signal generated by said image detector means.

The present invention will be described by way [redacted] accompanying diagrams, in which:

FIGURE 1 is a schematic diagram of a device for the detection and classification of the crimpling of a surface treatment designed in accordance with the present invention;

FIGURES 2, 3 and 4 illustrate the progression of some signals detected or calculated by the device shown in FIGURE 1 in three different operating conditions;

FIGURES 5, 6 and 7 are graphic representations obtained using the device shown in FIGURE 1 and referring to the operating conditions illustrated, respectively, in FIGURES 2, 3 and 4; and

FIGURE 8 shows an example, on an enlarged scale, of a possible operating condition that may arise during the use of the device shown in FIGURE 1.

With particular reference to FIGURE 1, the numeral 1 indicates a device for performing the detection and classification of the crimpling of a surface treatment. More specifically, device 1 may be beneficially used for the detection and classification of the crimpling of a layer 2 of paint deposited on a surface of a metal sheet 3 constituting the outermost part of a vehicle bodywork, for example, of a motorcar.

Device 1 is of the type comprising illuminating means 5 adapted to illuminate an area 6 to be examined of the surface of layer 2 by means of a luminous beam 7 essentially comprising a plurality

of light areas alternated with dark areas and with clearcut edges between the respective adjacent areas.

Said means 5 essentially comprise a light source 10 and a screen 11 displaying a plurality of opaque bars 12 alternated with transparent bars 13. In order to use device 1 correctly, source 10 and screen 11 should be set so that onto a surface of layer 2 of paint is reflected a lattice consisting of light and dark areas with clearcut adjacent edges.

In accordance with the present invention, device 1 comprises:
image detector means 15 adapted to explore area 6 of layer 2 by scansion, so as to obtain an alternate electrical signal on subsequent detection of the light and dark areas of said lattice; and
calculating means 16 which execute a mathematical calculation of the gradient of the signal generated by image detector means 15.

Image detector means 15 preferably comprise a telecamera set directly opposite source 10 and positioned so that the frame shows the area of incidence of beam 7.

The scan lines of telecamera 15 should be set perpendicular to the lattice bars projected on the surface of area 6 of layer 2; nevertheless, the method explained in the present invention and described subsequently provides for any setting between said telecamera and lattice, provided that it is set in a symmetrical, specular position.

The angle of incidence, indicated by the letter A, made by beam 7 with the surface of layer 2 is not fixed; for example, it could be 45°.

Device 1 also comprises comparing means 17 which carry out a comparative analysis of the bargraphs obtained at the end of an inspection of area 6 under examination, with preset reference values.

Calculating means 16 and comparing means 17 together form a video signal processing system 18 equipped with an output which directly supplies a display device 19 which may comprise, for example, a monitor and/or a printer (not illustrated).

FIGURES 2a, 3a and 4a show three different instances of reflection of luminous beam 7 by area 6 under examination, caused by three different degrees of crimpling (zero, medium, high) of the surface of layer 2 of paint. In said cases, telecamera 15 generates, during scansion of said surface performed using a scan line indicated by the letter S, three different electrical signals (FIGURES 2b, 3b, 4b), whose the absolute gradient value, calculated by calculating means 16, is given in FIGURES 2c, 2b, 2c, respectiv ly. Scanning of the surface of area 6 by t lecamera 15 should ideally be performed along lines which, as stated above, are set perpendicular to bars 12, 13 projected onto the surface of area 6.

FIGURES 5, 6 and 7 show the gradient/number of pixels bargraphs conveniently displayed on device 19 and obtained by means of processing system 18, on the output signal generated by telecamera 15, with reference to FIGURES 2, 3 and 4, respectively.

The gradient was calculated as an absolute value of the difference in amplitude of the video signal of nearby pixels of telecamera 15, and the maximum value reached is indicated by G0, G1 and G2, respectively, in FIGURES 5, 6 and 7.

We should like to point out that the graphic representations shown in FIGURES 5, 6 and 7 are true examples and are thus affected by the noise created during the acquisition and subsequent processing of the optical signal by telecamera 15 and processing system 18.

Finally, FIGURE shows the path of an elementary portion P of light source 10 illuminating a respective portion P' of area 6, and is focused on a corresponding portion P'' of the image plane of telecamera 15, by means of a focusing lens 20. Any disturbance, indicated by N', on a crimped surface of paint, causes luminous beam 7 to be reflected into an area N'' of the image plane of telecamera 15, in a position out of focus with portion P''.

It can clearly be seen that the data obtained using device 1 are little affected by concomitant, dotted superficial defects, as these defects are reflected totally out of focus and as detection is of a statistical type, based on a large number of pixels.

The method put forward in the present invention for the detection and classification of the crimpling of a surface treatment essentially comprises the following operations:
illumination of area 6 by luminous beam 7 essentially comprising a plurality of light areas alternated with dark areas and preferably with clearcut edges between the respective adjacent areas;
detection of the beam reflected by area 6 by means of image detecting means 15, which scan area 6 so as to obtain an alternate electrical signal on subsequent detection of said light and dark areas;
execution, by means 16, of a mathematical calculation of the gradient and corresponding number of pixels of said signal generated by image detecting means 15, and drawing of a gradient/number of pixels bargraph;
execution, by comparing means 17, of a comparative analysis of the bargraph, obtained at the end of an inspection of area 6, with preset reference values.

According to the type of paint surface crimpling, at the end of the inspection of the surface und r examination, different bargraphs are obtained, as is shown, for example, in FIGURES 5, 6

and 7. A study of the values obtained (G0, G1 and G2) provides an indication of the crimpling, which increases as the value calculated for the respective gradient on the graph decreases. For example, a severely crimped surface causes, along the edges between the dark and light areas, a gradual merging of these areas with a gradient which tends towards zero.

As far as the dimensions are concerned, the maximum width of bars 12 and 13 forming the lattice, irrespective of their position with respect to telecamera 15, is that defined by the optic lever represented by the maximum angle of inclination of the elementary portions constituting the crimped surface of layer 2, and by the distance between source 10 and the actual surface of layer 2. The maximum inclination considered must not permit the reflection, by said elementary portions of layer 2, of different bars of the same type (dark or light). The number of bars contained in the lattice displayed on screen 11, respecting the minimum dimensions established on the basis of the consideration set forth above, has no limits, provided that it does not prevent a valid statistical calculation from being made.

The classification of crimpling could be performed in the following way: first of all, the diagram under examination (FIGURES 5, 6 and 7) may be subdivided into various parts and the corresponding spread value defined on the basis of previously prepared samples. The number of pixels in each of these parts should also be taken into account: if this number is lower than the preset minimum, the spread value to be considered is the first, moving from the right-hand side of the diagram to the left-hand side, that exceeds said minimum.

From the examination of the features of the present invention, it can clearly be observed that the method and device presented offer numerous advantages.

First of all, this crimpling measurement is totally automatic and thus does not involve subjective assessments made by the operator, nor does it depend on the colour of the paint under examination.

Concomitant and dotted surface defects do not falsify the measurement as they are reproduced completely out of focus on the image plane of telecamera 15.

Any curves or inaccuracies on the lattice, or imprecise focusing do not affect the results of the measurements (the scale can be reset), and a wide range of distances between the telecamera and the area under examination are possible, keeping the diaphragm of the telecamera lens slightly open.

It was observed that, using inclined lattices, it is also possible to distinguish crimpling not oriented in a random fashion, and to detect a maximum crimpling value even with orientations defined using peculiarly conformed lattices, such as curves or concentric rings. If a projection with relative motion is to be effected between the area under examination and device 1, use may be made of a light source 10 that provides an intermittent luminous beam appropriately synchronized with the image filming means.

Modifications may be made to the method and the device set forth above, without exceeding the scope of the present invention.

For example, the method set forth above, though developped as a way of detecting and classifying the crimpling of the paint on a motorcar bodywork, may also be used to great advantage for performing similar tasks on any other type of surface treatment.

Claims

1. A method for the detection and classification of the crimpling of a surface treatment, characterized in that it comprises, in the following order, the operations listed below:
illumination of an area to be examined by means of of light areas alternated with dark areas and preferably with clearcut edges between the respective adjacent areas;
detection of a beam reflected by said area under examination using image detector means adapted to explore said area by scansion, so as to obtain an alternate electrical signal on subsequent detection of said light and dark areas;
execution of a mathematical calculation of the gradient and corresponding number of pixels of said signal generated by said image detector means, and create a bargraph showing the gradient in function of the number of pixels; and
comparative analysis of the bargraph, obtained at the end of an inspection of said area under examination, with preset reference values.

2. A method as claimed in claim 1, characterized in that it comprises the displaying of the values calculated for said gradients so as to obtain, at the end of scansion of said area under examination, a diagram in which the values calculated for said gradients are indicated in relation to the number of pixels of said image detectors; said diagram being subdivided into various parts each defining, by comparison with previously prepared samples, a corresponding spread value.

3. A method as claimed in claim 1 or 2, characterized in that the illumination of said area under examination is performed using an intermittent luminous beam.

4. A method as claimed in any of the previous claims, characterized in that it comprising relative maneouvring of said luminous beam and image detecting means in relation to said area under examination.

5. A device for the detection and classification of the crimpling of a surface treatment, of the type comprising illuminating means adapted to illuminate an area to be examined of said surface by means of a luminous beam essentially comprising a plurality of light beams alternated with dark beams and with clearcut edges between the respective adjacent areas, said device being characterized in that it comprises:
image detector means (15) adapted to explore said area (6) by scansion, so as to obtain an alternate electrical signal on subsequent detection of said light areas (13) and dark areas (12); and
calculating means (16) which execute a mathematic calculation of the gradient of said signal generated by said image detector means (15).

6. A device as claimed in claim 5, characterized in that said illuminating means (5) comprise a light source (10) and a screen (11) equipped with a plurality of opaque portions (12), alternated with transparent portions.

7. A device as claimed in claim 6, characterized in that said opaque and transparent portions (13, 12) are essentially straight.

8. A device as claimed in claim 6, characterized in that said opaque and transparent portions (13, 12) are curved.

9. A device as claimed in claim 8, characterized in that said curved portions are essentially annular and concentric.

10. A device as claimed in any of claims 5 to 9, characterized in that said opaque and transparent portions have essentially the same width.

11. A device as claimed in any of claims 5 to 10, characterized in that said opaque and transparent portions (13, 12) form a lattice and the minimum width of which is defined by the optical lever represented by the maximum angle of inclination of elementary portions forming the crimpled surface of said area (6) under examination and by the distance between said light source (10) and the surface of said area (6), so that the maximum inclination considered does not cause reflection, by said elementary portions of said area (6), of opaque or transparent portions of the same type.

12. A device as claimed in any of claims 5 to 11, characterized in that said image detecting means comprise at least one telecamera (15).

13. A device as claimed in any of claims 5 to 12, characterized in that it comprises comparing means (17) that carry out a comparative analysis of said bargraph, obtained at the end of scansion of said area (6), with preset reference values.

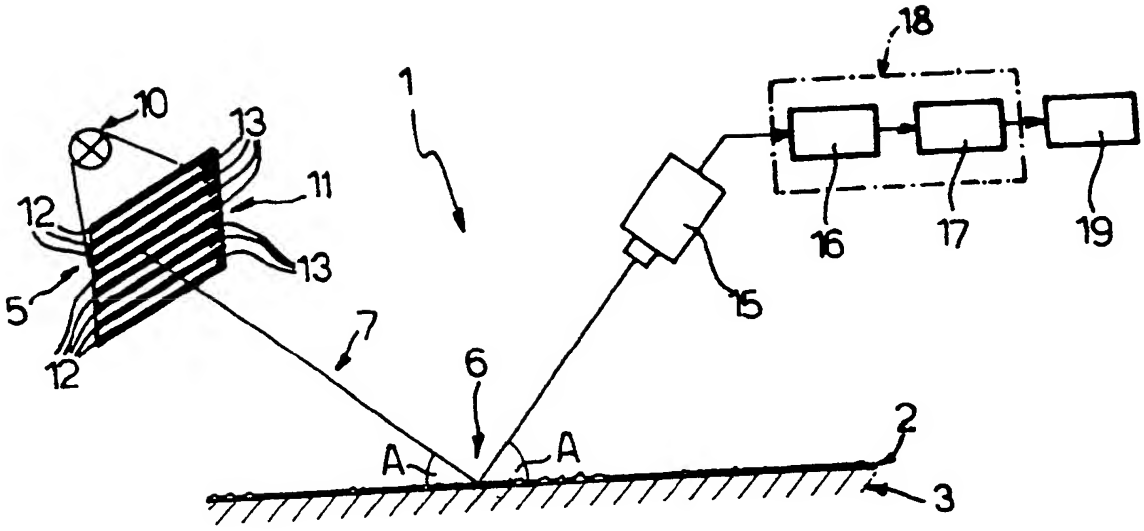

Fig. 1

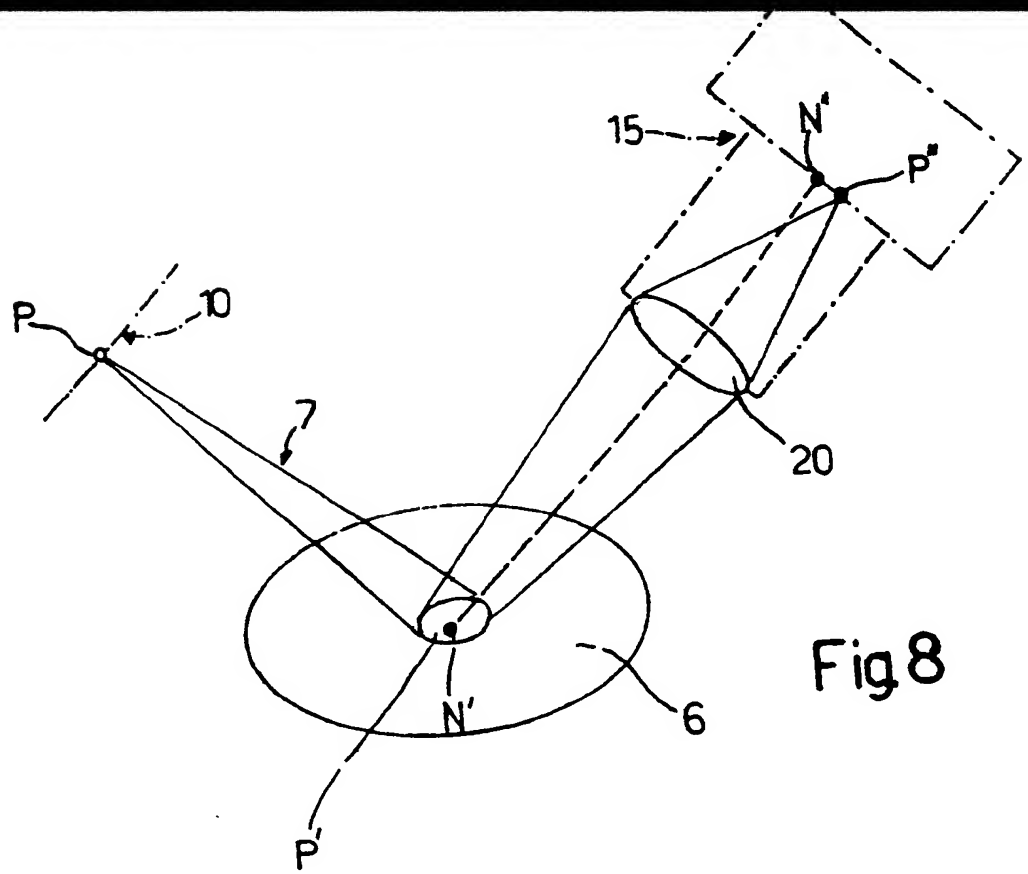

Fig. 8

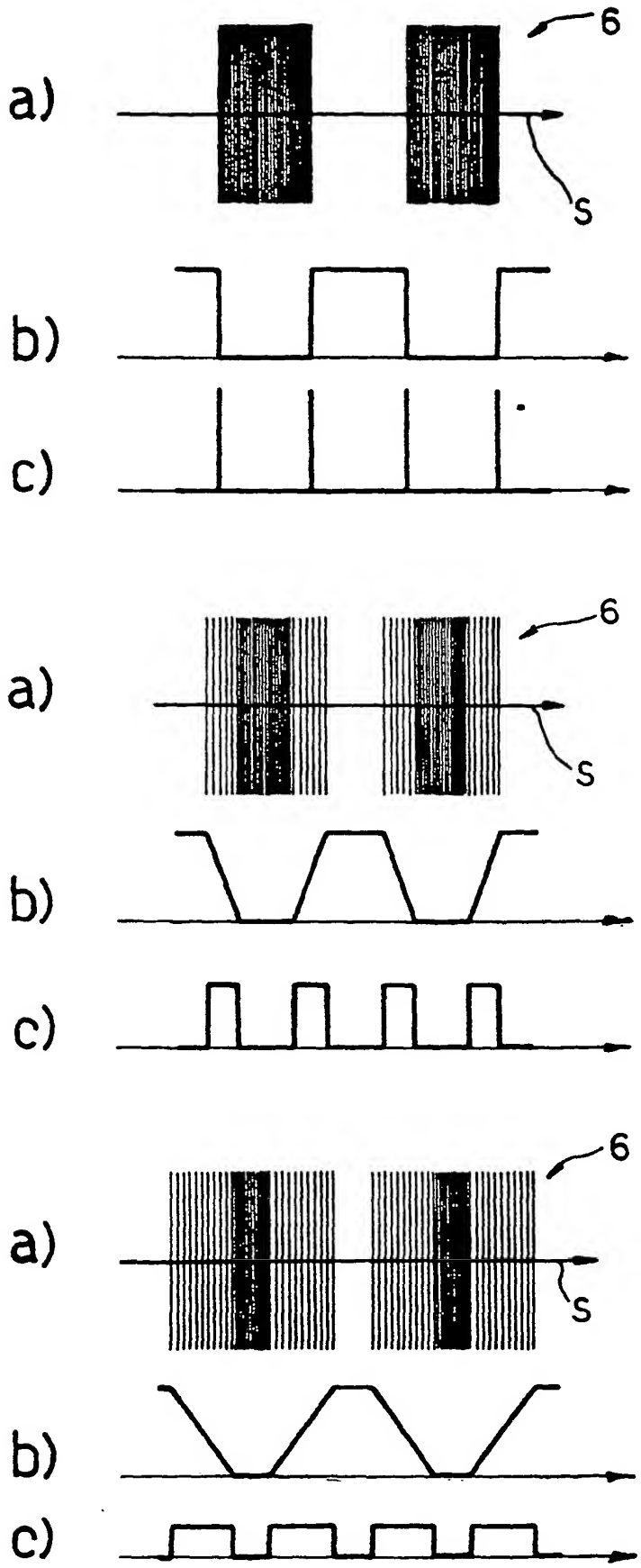

Fig.2

Fig.3

Fig.4

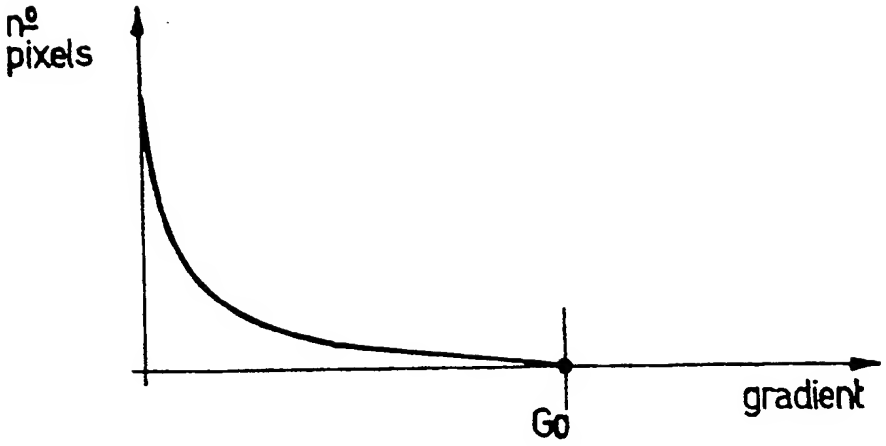

Fig. 5

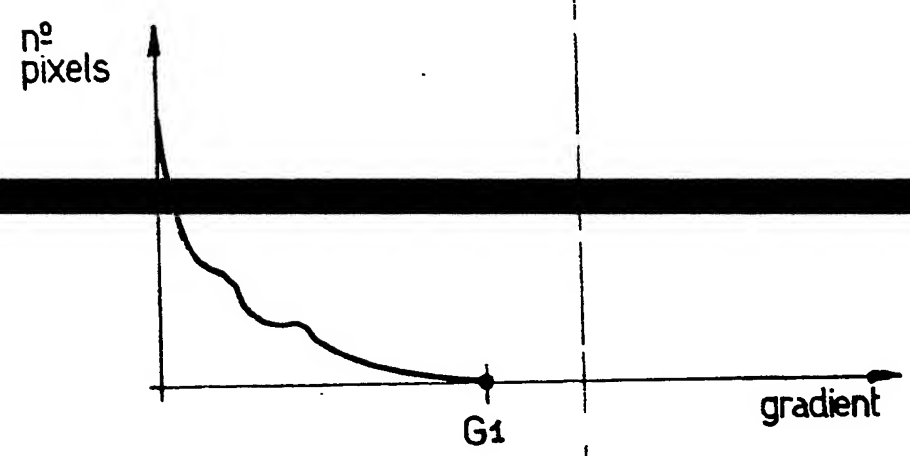

Fig.6

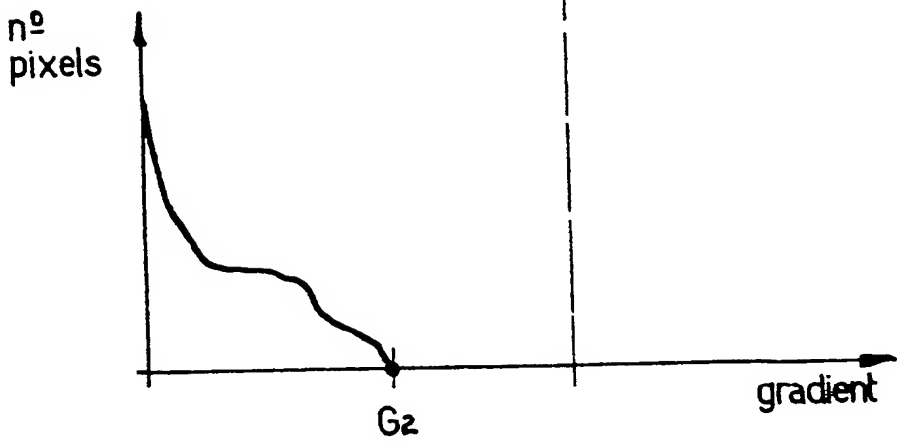

Fig.7

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EUROPEAN SEARCH REPORT

Application Number

EP 89 12 4018

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
Y	PATENT ABSTRACTS OF JAPAN, vol. 7, no. 262 (P-238)[1407], 22nd November 1983; & JP-A-58 144 731 (HITACHI) * Abstract * ---	1,5,6, 12	G 01 B 11/30
Y	US-A-4 682 041 (TOYOTA) * Column 4, lines 6-57; fig. * ---	1,5-7, 12-15	
Y	JP-A-5 271 289 (MITSUBISHI) * Abstract * ---	1,5-7, 12-15	
A	US-A-2 867 149 (C.T. GODDARD) * Column 2, lines 9-74; fig. * ---	1,5-7, 12	
A	PATENT ABSTRACTS OF JAPAN, vol. 9, no. 257 (P-396)[1980], 15th Ocotber 1985; & JP-A-60 107 506 (HITACHI) * Abstract * ---	1,5-9	
A	PATENT ABSTRACTS OF JAPAN, vol. 7, no. 224 (P-227)[1369], 5th October 1983; & JP-A-58 115 313 (MATSUSHITA) * Abstract * ---	1,5	TECHNICAL FIELDS SEARCHED (Int. Cl.5) G 01 B 11
A	PATENT ABSTRACTS OF JAPAN, vol. 7, no. 198 (P-220)[1343], 2nd September 1983; & JP-A-58 97 608 (NIPPON PAINT) * Abstract * -----	1,5	

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	07-02-1990	RAMBOER P.

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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